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X-ray Fluorescence Analysis with Cryogenic, High-Resolution X-ray Spectrometers

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Abstract

At Lawrence Livermore National Laboratory we are developing cryogenically-cooled, broad-band, high-resolution X-ray spectrometers which can be used for X-ray fluorescence and microanalysis. Our X-ray spectrometers are superconducting microcalorimeters based on superconducting tunnel junction sensors. The energy resolution of such cryogenically-cooled detectors operating at temperatures of a few 100 mK can be more than an order of magnitude better than that of the best Si(Li) or germanium detectors.

In this presentation we will give a brief general introduction to cryogenic detectors. We will describe the operating principle of our tunnel-junction-based spectrometers and the cryogenic system in which they are operated. We will then present results from two recent demonstration experiments performed with our small prototype detectors at the Stanford Synchrotron Radiation Laboratory. In a first series of experiments we irradiated our detectors directly with the monochromatized synchrotron beam and demonstrated the high count rate capability and good energy resolution of our detectors. At a total count rate of 2.5 kHz we measured a FWHM energy resolution of 8 eV at 277 eV incident energy (corresponding to C K); at a rate of 18 kHz the resolution was 23 eV at the same energy. The second series of experiments were X-ray fluorescence measurements on samples containing transition metals, low-Z elements and protein molecules. Both sereis of measurements showed that our cryogenic detectors can easily be implemented and opearated at synchrotron beam lines and in other room temperature systems. In the near future such detectors may prove very useful in X-ray fluorescence and microanalysis applications.

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